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MORTALITY OF CHILDHOOD

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The mortality of childhood ... / by Louis

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BY

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1918

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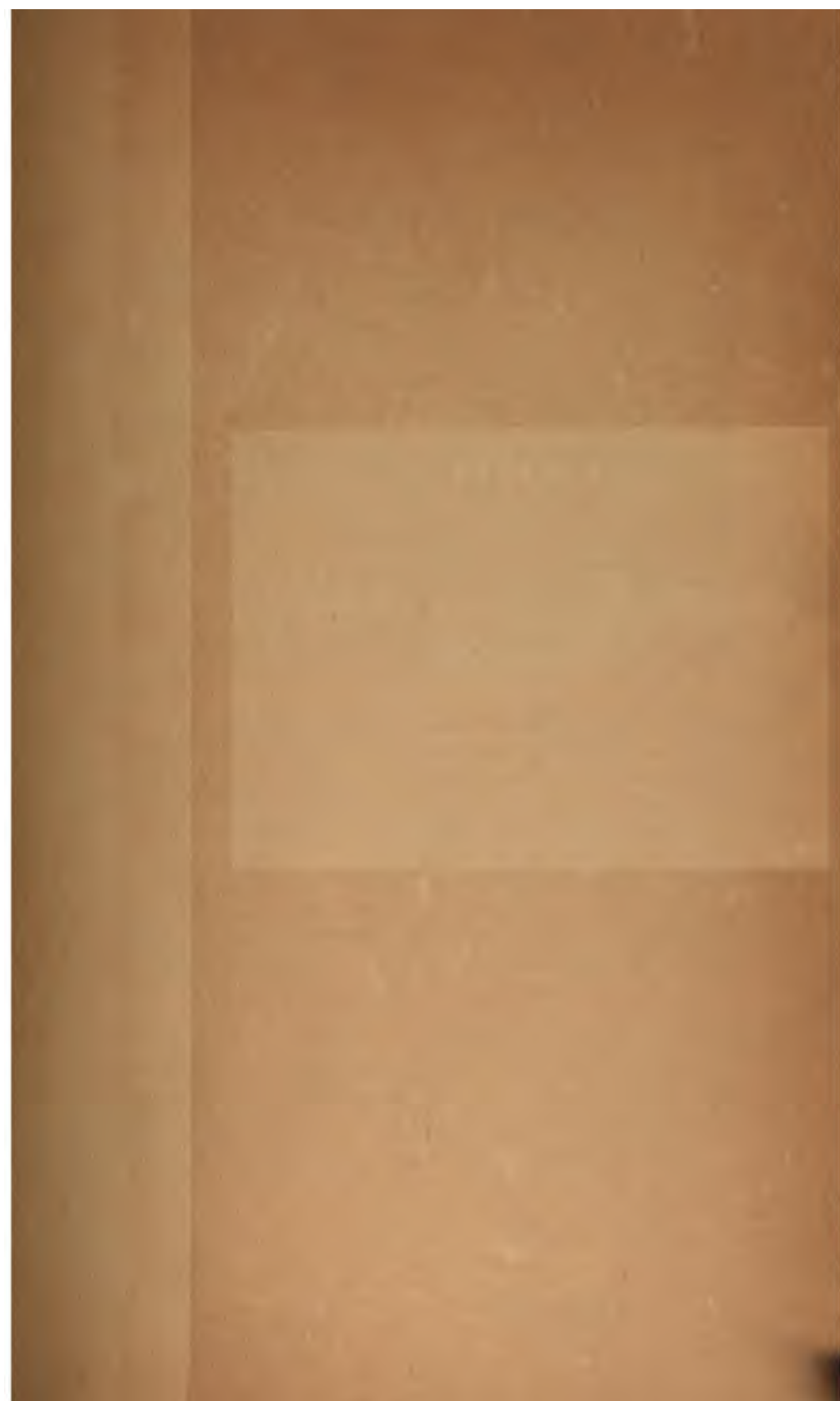
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THE MORTALITY OF CHILDHOOD.*

There are few authoritative papers in American vital statistics on the mortality of childhood. Such as have appeared, moreover, have been limited for the most part to infant mortality. The other divisions of child life, *i.e.*, the pre-school years and the interesting years of school life, have been virtually overlooked. The annual mortality reports of the United States Bureau of the Census contain the crude basic data on deaths at these ages but make no attempt to analyze the figures. The reports of the health departments of a very few states and cities contain references to their child mortality; but these are casual and scattered and have no great scientific value. In spite of the great interest and importance of the subject, there is today no phase of the whole mortality problem in the United States for which we have less definite information. The public health programme for the conservation of child life has undoubtedly been hampered as a result.

In this paper we shall attempt to bring together the facts with regard to child mortality that are available for the Registration Area of the United States and for a large group of insured children in the families of wage earners in the United States and Canada. The figures which we shall present have, to be sure, some limitations which we shall point out as we proceed. Our prime emphasis throughout will be on the practical uses of these data in public health work for children. First we shall consider the mortality of children for all causes of death combined and later, for the chief causes of death in each of the principal age periods of childhood.

MORTALITY OF CHILDREN: ALL CAUSES OF DEATH COMBINED.

There are two outstanding facts with regard to child mortality: childhood is ushered in with the highest mortality rate and closes with the lowest rate of any divisional period

* Paper read at the Seventy-ninth Annual Meeting of The American Statistical Association.

of life. There is, accordingly, a very rapid downward sweep in the death rate from age to age throughout childhood. The mortality during childhood should, therefore, be studied by single years of age; at any rate, during the first five years of life where the most marked changes occur from age to age. After the first quinquennium the mortality may readily be studied by five year periods of age. The following table presents the mortality rates for male and female children under age 15. The figures cover the six year period 1910 to 1915 for the expanding Registration Area of the United States. The populations have been estimated by means of the arithmetic annual increment method, using the annual estimates of total population for the Registration Area and distributing the sum by sex and age period on the basis of the distribution found by the 1910 Census.

TABLE I.
ESTIMATED POPULATION,* DEATHS AND DEATH RATES PER 1,000, EXPANDING REGISTRATION AREA OF UNITED STATES, 1910 TO 1915, AGES UNDER 15 YEARS. MALES AND FEMALES COMPARED.

| Age Period. | Males. | | | Females. | | |
|---------------------|-----------------------|---------|-----------------|-----------------------|---------|-----------------|
| | Estimated Population. | Deaths. | Rate per 1,000. | Estimated Population. | Deaths. | Rate per 1,000. |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Under 1..... | 4,079,018 | 513,338 | 125.8 | 3,965,102 | 400,883 | 101.1 |
| 1..... | 3,635,315 | 99,319 | 27.3 | 3,535,519 | 88,256 | 25.0 |
| 2..... | 3,987,611 | 43,682 | 11.0 | 3,875,231 | 39,129 | 10.1 |
| 3..... | 3,940,004 | 27,156 | 6.9 | 3,884,218 | 24,549 | 6.3 |
| 4..... | 3,894,300 | 19,732 | 5.1 | 3,779,968 | 17,868 | 4.7 |
| Total under 5..... | 19,536,248 | 703,227 | 36.0 | 19,040,038 | 570,685 | 30.0 |
| 5 to 9..... | 17,609,764 | 58,378 | 3.3 | 17,257,519 | 52,205 | 3.0 |
| 10 to 14..... | 16,870,390 | 38,653 | 2.3 | 16,603,960 | 35,135 | 2.1 |
| Total under 15..... | 54,016,402 | 800,258 | 14.8 | 52,901,517 | 658,025 | 12.4 |

*Thanks are due to the Prudential Insurance Company and to the Census Bureau for basic data used in estimating these populations.

Columns 4 and 7 in Table I show the death rates for males and females respectively in the several age periods. The highest mortality occurs, of course, under age one; 125.8 and 101.1 for males and females respectively. These figures must be distinguished from the so-called infant mortality rates which are based on the number of births reported. A

sharp decline is observed in the death rate for the next year of life, between age one and two. The rates are then 27.3 and 25.0 for males and females. The rate of decline during the next three years of life is less marked. At the age period two to three years the rates are 11.0 and 10.1 for males and females and in the next age period, three to four years, the rates reach the comparatively low figures of 6.9 and 6.3 per 1,000 for males and females. At age four to five years the figures are 5.1 and 4.7 per 1,000 for males and females respectively. After age 5, the decline in the death rate is slight for each succeeding individual year. For the entire age period five to nine years the death rate is for both sexes but slightly over 3 per 1,000. For the period 10 to 14 years the rate is not much more than 2 per 1,000 exposed. The minimum during the whole range of life is then attained. It should be noted that the mortality rates for males are uniformly higher than for females throughout the entire period of childhood, although it has been widely observed that the rates for the two sexes converge almost to identity at about age 13. After this point, the rates for the two sexes diverge again, the females showing progressively lower figures of mortality than the males. The general trend of the rates is, however, much the same for each sex.

The rates of mortality in this table apparently are regular in their downward course and in themselves do not suggest any internal technical difficulties. It is a well established fact, however, that the estimated population of the ages of childhood based upon the Census enumerations is far from perfect. The population under 1 year of age is practically always under-enumerated. The enumeration of population at the period one to two years is also too low as is indicated in columns 2 and 5 of Table I by the fact that the number is less than for any succeeding year in the period 1 to 5. Thereafter, the ages 2, 3 and 4 last birthday do not present substantial difficulties for our purposes. The number of persons living declines with each succeeding year of age in practical accordance with the death rate at these ages. We may, therefore, say that the mortality rates presented in columns 4 and 7 are somewhat higher than they should be in

the first two years of life and that thereafter up to age 15 they probably approach closely to the true facts of child mortality in the area covered.

To overcome the difficulties involved in the above table which result from the defective enumeration of children at the youngest ages, we may profitably use the figures in the recently prepared United States Life Tables 1910. In these tables, Prof. J. W. Glover, who supervised the compilations, smoothed or graduated the populations recorded at the several age periods of childhood, following the method employed in the preparation of the German tables for the period 1891 to 1900. As a result of these smoothing processes, he obtained rates which are in all probability a closer approach to the true facts of mortality for the individual years of life in childhood than are the unadjusted figures presented in Table I. We present in Table II the values obtained by Professor Glover. They cover the three calendar years 1909 to 1911 and relate to the original registration states as constituted in 1900. It should be noted that these figures are not central death rates but are based upon the estimated populations at the beginning of each age period.

TABLE II.
DEATH RATES AT SINGLE AGES UNDER FIVE YEARS AND BY FIVE YEAR AGE PERIODS
THEREAFTER UP TO AGE FIFTEEN, ORIGINAL REGISTRATION STATES—1909-1911.
MALES AND FEMALES COMPARED.

| Age Period. | Death Rate per Thousand. | |
|---------------------|--------------------------|----------|
| | Males. | Females. |
| 0-1..... | 125.0 | 103.8 |
| 1-2..... | 28.8 | 26.4 |
| 2-3..... | 13.0 | 11.6 |
| 3-4..... | 8.1 | 7.6 |
| 4-5..... | 5.8 | 5.5 |
| Total under 5..... | 39.3 | 33.2 |
| 5-10..... | 3.6 | 3.3 |
| 10-15..... | 2.4 | 2.2 |
| Total under 15..... | 15.7 | 13.3 |

A comparison of the rates in Tables I and II confirms the essential facts already brought out with regard to the mortality from all causes combined in the period of childhood. The death rate for males in childhood is at every point higher

than for the females. The rates of decline in mortality from age period to age period are also much alike in both tables. In fact, beginning with age 4 last birthday, the figures for the Registration States 1909 to 1911 and for the Registration Area 1910 to 1915 are very much alike. Such differences as appear in the two tables after age four are probably due to the somewhat different areas covered and to the different years of experience employed. The mortality rate of children has been somewhat on the decline since 1910 and this is shown in the lower rates in the later figures for the Registration Area. Figures prepared by us for the Registration Area for the years 1909, 1910 and 1911 approach the Glover figures much more closely.

TABLE III.

DEATH RATES PER 1,000. EXPANDING REGISTRATION AREA, 1910 to 1915, ORIGINAL REGISTRATION STATES, 1909 to 1911, AND WHITE LIVES, INDUSTRIAL DEPARTMENT, METROPOLITAN LIFE INSURANCE COMPANY, 1911 to 1916 COMPARED. SINGLE YEARS OF AGE UNDER FIVE; FIVE YEAR AGE PERIODS THEREAFTER UP TO AGE FIFTEEN.

| Age Period. | Males. | | | Females. | | |
|------------------|------------------------------|---------------------------------|--------------------------------------|------------------------------|---------------------------------|--------------------------------------|
| | Exp. Reg. Area 1910 to 1915. | Orig. Reg. States 1909 to 1911. | M.L.I. Co. White Ind'l 1911 to 1916. | Exp. Reg. Area 1910 to 1915. | Orig. Reg. States 1909 to 1911. | M.L.I. Co. White Ind'l 1911 to 1916. |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Under 1..... | 125.8 | 125.0 | — | 101.1 | 103.8 | — |
| 1..... | 27.3 | 28.8 | — | 25.0 | 26.4 | — |
| 2..... | 11.0 | 13.0 | — | 10.1 | 11.6 | — |
| 3..... | 6.9 | 8.1 | 8.1 | 6.3 | 7.6 | 7.6 |
| 4..... | 5.1 | 5.8 | 6.0 | 4.7 | 5.5 | 5.5 |
| Total under 5... | 39.0 | 39.3 | — | 30.0 | 33.2 | — |
| 5 to 9..... | 3.3 | 3.6 | 3.6 | 3.0 | 3.3 | 3.3 |
| 10 to 14..... | 2.3 | 2.4 | 2.3 | 2.1 | 2.2 | 2.2 |
| Total under 15.. | 14.8 | 15.7 | — | 12.4 | 13.3 | — |

A third source of data is available in the mortality figures for the Industrial Department of the Metropolitan Life Insurance Company, which has a large exposure of children. Unfortunately, the actuarial* necessities of the case make a

* The insurance experience contains no children under one year of age. This experience is also compiled on the "Calendar year basis," that is, the age of the lives exposed is automatically advanced one year on each January 1 irrespective of the actual age of the insured at that time. This actuarial process results in advancing the ages of the young children so appreciably that the rates obtained for ages 1 and 2 last birthday are not comparable with population rates. Beginning with age 3 last birthday and thereafter the processes of the calendar year method balance each other at the beginning and at the end of each year of age and the rates obtained are, as a result, comparable with population figures for the same ages.

comparison of the data impossible for the ages one and two last birthday. Thereafter, that is, beginning with age 3, the rates are, as is seen in columns 4 and 7 of Table III, consistent with those previously presented in Tables I and II and indicate that the insurance experience for the children of the wage earners of America approximates fairly well the mortality of children in the general population. Limitation is made in these insurance figures to white lives and the period covered is for the six years 1911 to 1916. The experience includes nearly all the states of the United States and the Provinces of Canada.

PRINCIPAL CAUSES OF DEATH IN CHILDHOOD.

Certain diseases and conditions are preëminently those of childhood. The causes peculiar to early infancy, the acute infectious diseases such as measles, scarlet fever, whooping cough and diphtheria, and the nutritional diseases such as infantile diarrhea and enteritis, are encountered almost entirely in children under 15 and have a negligible incidence beyond that age. On the other hand, conditions such as tuberculosis, all forms of pneumonia, and certain traumatisms, while more or less prevalent in childhood are found appreciably in other periods of life. Interest centers in the diseases of childhood because they have proved a very fruitful field of research for the medical investigator even if much promising work still remains to be carried out. A consideration of the causes of death in childhood is, moreover, indispensable from the standpoint of public health service and the prevention of disease generally. We shall in the following discussion consider the several important causes of death in each one of the age periods, both as to relative importance and as to the actual rates of mortality incidence. For this purpose we shall use as our basic material the returns for the expanding Registration Area for the 6-year period from 1910 to 1915 and the data of the Industrial Department, Metropolitan Life Insurance Company, from 1911 to 1916. It is encouraging in connection with this proposed discussion that we are concerned with deaths that are, for the most part, well reported and fairly reliably stated as to cause.

THE FIRST YEAR OF LIFE.

In the first year of life, a very few diseases and conditions account for the larger part of the mortality. Thus, the group of conditions included under the terms congenital debility and malformations and the injuries at birth together account for 37.6 per cent. of the total. Next in importance we find diarrhea and enteritis with 24.4 per cent. of the total deaths. The respiratory diseases which are for the most part bronchopneumonia, but which literally include lobar and undefined pneumonia as well as bronchitis, are together responsible for 15.5 per cent. of the deaths. We see, therefore, that three groups of causes alone account for nearly four-fifths of the total mortality of the first year of life (77.5 per cent.).

The remainder of the mortality is distributed over a considerable number of conditions no one of which is of preëminent importance. The four important communicable diseases of childhood, which we shall find very prominent in our discussion at the other age periods, are not represented to any large degree in the first year of life, with perhaps the exception of whooping cough which accounts for 2.3 per cent. of the total deaths. The highest rate for whooping cough at any age is found in the initial year of life. In fact, over one-half of all the deaths from this disease are located in this first age group. A large proportion of the deaths from measles are also found in this first year of life. The relative significance of measles to all causes is not as great, however, as we shall find it in the later periods. Tuberculosis looms larger in this age period than any of the acute infectious diseases named, except whooping cough. About one-half of the tuberculosis deaths are from tuberculous meningitis. Finally, syphilis, which is undoubtedly under-registered at present, is noted in 1.2 per cent. of the total deaths. In view of the high total mortality, we find the rate for this condition extraordinarily high, 137.6 per 100,000; higher in fact than is found at any other age period in life. Other diseases such as meningitis, convulsions, "other diseases of the stomach" and the "ill-defined diseases" are so unreliable in their certification that it is not desirable to refer to them in any fulness. As regis-

tration improves, they will be found more and more under the more definite titles referred to above. At present, however, they account for an appreciable part of the infant mortality.

The following table presents the important conditions in the first year of life, giving the percentage of each cause to all causes as well as the rate per 100,000 exposed at the age period. It was not thought necessary to give any detailed analysis of the figures by sex because the conditions affect the two sexes very similarly. Noteworthy sex differences appear only for whooping cough which is more prevalent as a cause of death among females, and for the causes peculiar to early infancy, such as injuries at birth, which are much more frequent as causes of death of male babies. This fact is in agreement with what is well known in obstetrical practice, namely, that the larger male baby is more subject to injury than the smaller female child.

Since no insurances are written by the Metropolitan on the lives of children under one year of age no comparative insurance mortality data can be quoted for the first year of life.

TABLE IV.
CAUSES OF DEATH IN FIRST YEAR OF LIFE. PERCENTAGE OF TOTAL DEATHS AND RATES PER 100,000, EXPANDING REGISTRATION AREA OF THE UNITED STATES 1910-1915.

| Cause of Death. | Per cent. Total Deaths. | Rate per 100,000. |
|--|-------------------------|-------------------|
| All causes..... | 100.0 | 11365.1 |
| Whooping cough..... | 2.3 | 257.2 |
| Tuberculosis—all forms..... | 1.6 | 183.8 |
| Tuberculosis of the lungs..... | .6 | 66.4 |
| Tuberculous meningitis..... | .8 | 84.7 |
| Syphilis..... | 1.2 | 137.6 |
| Bronchitis..... | 2.5 | 280.1 |
| Bronchopneumonia..... | 8.1 | 919.1 |
| Pneumonia—lobar and undefined..... | 4.9 | 551.4 |
| Diarrhea and enteritis..... | 24.4 | 2768.6 |
| Congenital malformations—total..... | 5.6 | 637.5 |
| Hydrocephalus..... | .4 | 43.3 |
| Congenital malformations of the heart..... | 3.5 | 392.2 |
| Other congenital malformations..... | 1.8 | 202.0 |
| Congenital debility, icterus and sclerema—total..... | 25.9 | 2946.3 |
| Premature birth..... | 16.8 | 1909.6 |
| Congenital debility, "atrophy," marasmus..... | 9.1 | 1036.7 |
| Other causes peculiar to early infancy—total..... | 6.1 | 695.0 |
| Injuries at birth..... | 3.3 | 370.1 |
| Other causes peculiar to early infancy..... | 2.7 | 301.0 |

THE SECOND YEAR OF LIFE.

The causes responsible for the mortality during the second year of life present a somewhat different picture from that found in the earlier year. The conditions associated with prematurity and with the congenital defects are no longer present to any degree. On the other hand, diarrhea and enteritis continue to play a most important part in the total mortality and are, in fact, the first causes of all in the second year of life; over one quarter of the deaths (27.3 per cent.) are due to this single condition. Next in importance are the respiratory diseases which include bronchopneumonia, pneumonia lobar and undefined and bronchitis. They were responsible for 26.4 per cent. of the deaths in the second year of life. Bronchopneumonia still accounts for the most part of these deaths. The four epidemic diseases, measles, scarlet fever, whooping cough and diphtheria now play a much more prominent part in the total mortality. Together, they account for 17.8 per cent. of all the deaths. Diphtheria is the most important of the four and reaches its highest death rate in any year of life. It is followed by measles with nearly the same rate and by whooping cough and scarlet fever in the order named. Tuberculosis rises in this year into a more prominent position, relatively, than in the first year of life but the actual rate per 100,000 exposed, is somewhat lower. Tuberculous meningitis forms over one-half of the total tuberculosis mortality. Finally, we must take the accidents into consideration, in this second year of life; burns alone now are responsible for 1.7 per cent. of the deaths with a rate of 44.1 per 100,000 exposed and, as we shall see, this condition as well as other accidental causes becomes more and more prominent with the advancing ages of childhood.

Males showed higher mortality rates than females in the second year of life for measles (154 and 142, respectively, per 100,000), scarlet fever (47 and 41 per 100,000), diphtheria and croup (164 and 138 per 100,000), tuberculosis, all forms (156 and 141 per 100,000), tuberculous meningitis (83 and 78 per 100,000), bronchopneumonia (393 and 358 per 100,000), pneumonia, lobar and undefined (266 and 232 per 100,000)

and diarrhea and enteritis (747 and 678 per 100,000). Whooping cough showed a higher female rate (138 per 100,000). The male rate was 105 per 100,000.

As before, there is an appreciable mortality registered for conditions such as dysentery, meningitis, "other diseases of the stomach" and "ill-defined diseases," which are reported so unreliably that no reference is made to them in our Table V which follows:

TABLE V.
CAUSES OF DEATH IN SECOND YEAR OF LIFE. PERCENTAGE OF TOTAL DEATHS AND RATES PER 100,000, EXPANDING REGISTRATION AREA OF THE UNITED STATES 1910-1915.

| Cause of Death. | Per Cent. Total Deaths. | Rate per 100,000. |
|------------------------------------|-------------------------|-------------------|
| All causes..... | 100.0 | 2615.8 |
| Measles..... | 5.7 | 148.1 |
| Scarlet fever..... | 1.7 | 43.9 |
| Whooping cough..... | 4.6 | 120.9 |
| Diphtheria and croup..... | 5.8 | 151.0 |
| Tuberculosis—all forms..... | 5.7 | 148.2 |
| Tuberculosis of the lungs..... | 1.8 | 47.1 |
| Tuberculous meningitis..... | 3.1 | 80.7 |
| Bronchitis..... | 2.5 | 65.3 |
| Bronchopneumonia..... | 14.4 | 375.9 |
| Pneumonia—lobar and undefined..... | 9.5 | 249.1 |
| Diarrhea and enteritis..... | 27.3 | 713.2 |
| Burns..... | 1.7 | 44.1 |

THE THIRD YEAR OF LIFE.

The facts of this age period show a further shift in the relative importance of the several causes of death. The four chief epidemic diseases are now of the first importance, being responsible together for more than one fourth of the deaths (26.4 per cent.). Diphtheria is by far the most prominent of the four and its rate is not much less than for the second year of life when the mortality from all causes was more than twice as great. Scarlet fever while now relatively more prominent has much the same rate as in the preceding year; but the rates for measles and whooping cough have dropped to a little more than one third what they were in the second year. The respiratory conditions including the same diseases listed in the previous discussion, are now responsible for 22.0 per cent. of the total mortality. Bronchopneumonia is still the chief item in this list. Diarrhea and enteritis have de-

clined perceptibly in their proportionate incidence and even more so in the rate, although their importance is not yet to be discounted. The proportionate incidence of tuberculosis has increased also, although the rate per 100,000 has decreased to about one half of the previous one. Tuberculous meningitis is again the prominent form of tuberculosis in this year of life. Accidents and injuries, as might be expected, play an increasingly important part. It is at this age that children begin to manifest extraordinary curiosity about the affairs of the household and their environment generally and indulge in all the activities of the runabout-child. Burns are the most important of the accidental causes of death, being responsible for 4.3 per cent. of the deaths. The rate is practically the same as in the preceding year. We also observe that falls begin at this age period to become an important cause of mortality among children. Attention should also be directed to the beginning importance of typhoid fever, which now is responsible for 1 per cent. of the deaths with a rate of 10.3 per 100,000 exposed.

Measles shows only a slightly higher death rate for males than for females as does also scarlet fever, tuberculosis, all forms, tuberculous meningitis, and bronchopneumonia. Diphtheria mortality is considerably higher for males (136 per 100,000) than for females (122 per 100,000). Pneumonia, lobar and undefined shows a male rate of 98 which may be compared with a female rate of 89 per 100,000. Diarrhea and enteritis shows rates of 143 and 130 per 100,000 for males and females respectively in the third year of life. Burns show a male mortality rate of 49 and a female rate of 40 per 100,000. Traumatism by fall shows, comparatively, a rate of 11 for males and 7 per 100,000 for females.

Several conditions such as dysentery, meningitis, acute nephritis, acute poisonings and ill-defined diseases are registered in significant proportions but their rates, in view of the declining total mortality, are not large enough to warrant any extended treatment, especially in view of the indefinite character of most of these titles or of their unreliability as statements of cause of death. The chief facts for the third year of life are shown in Table VI.

automobile accidents and injuries where the male rate was 4 per 100,000 and the female rate was only 2 per 100,000.

The ill-defined causes of death and a number of others which are in effect terminal conditions of the acute infections are present in this age group as before, but find no proper place in our Table VII which follows:

TABLE VII.
CAUSES OF DEATH IN FOURTH YEAR OF LIFE. PERCENTAGE OF TOTAL DEATHS AND RATES PER 100,000, EXPANDING REGISTRATION AREA OF THE UNITED STATES 1910-1915, AND METROPOLITAN LIFE INSURANCE CO., INDUSTRIAL DEPARTMENT, WHITE LIVES, 1911 TO 1916.

| Cause of Death. | Per cent. Total Deaths. | | Rate per 100,000. | |
|------------------------------------|-------------------------|------------|-------------------|------------|
| | Reg. Area. | M.L.I. Co. | Reg. Area. | M.L.I. Co. |
| All causes..... | 100.0 | 100.0 | 660.8 | 788.8 |
| Typhoid fever..... | 1.5 | 1.4 | 10.2 | 11.1 |
| Measles..... | 4.4 | 5.7 | 29.1 | 45.3 |
| Scarlet fever..... | 7.0 | 5.8 | 46.1 | 46.1 |
| Whooping cough..... | 3.2 | 3.5 | 21.1 | 27.9 |
| Diphtheria and croup..... | 17.0 | 18.1 | 112.2 | 147.2 |
| Tuberculosis—all forms..... | 7.7 | 7.2 | 50.5 | 56.9 |
| Tuberculosis of the lungs..... | 2.3 | 1.7 | 15.3 | 13.0 |
| Tuberculous meningitis..... | 4.0 | 4.4 | 26.7 | 34.7 |
| Bronchitis..... | 1.4 | 1.7 | 8.9 | 13.2 |
| Bronchopneumonia..... | 7.8 | 9.3 | 51.4 | 73.0 |
| Pneumonia—lobar and undefined..... | 7.6 | 7.1 | 50.5 | 56.1 |
| Diarrhea and enteritis..... | 7.3 | 8.0 | 48.4 | 62.7 |
| Burns..... | 5.9 | 5.0 | 38.8 | 39.4 |
| Traumatism by fall..... | 1.0 | 1.1 | 6.8 | 8.4 |
| Total vehicular accidents..... | 1.6 | 1.6 | 10.5 | 12.9 |

THE FIFTH YEAR OF LIFE.

In the last of the first five years of life, the total mortality rate has again declined from that of the preceding year. The changes of the relative importance of the individual conditions are also few and unimportant both in the insurance and general population experiences. In fact much the same picture is presented by Table VIII as in the preceding one; our discussion of this age is, therefore, necessarily brief. Attention need be directed only to the increasing prominence of typhoid fever, to the appearance for the first time of appendicitis as a condition deserving comment, and to the presence of the organic heart diseases which are the cause of 1.6 per cent. of all the deaths in the fifth year of life among population

children, and for 1.2 per cent. among deaths of insured children. It is possible, of course, that the latter diseases as well as acute nephritis which we have not included in our table but which is also reported in 1.3 per cent. of the deaths of population children, are in large measure the sequelae of the epidemic diseases. Reference should also be made to the increasing incidence of the vehicular accidents which are in this age period responsible for 2.5 per cent. of the total mortality in both experiences. The automobile accidents are by far the most prominent of the individual conditions under this head.

Apart from a few conditions, there are no very significant differences between the population and insurance experiences among children in this year of life.

TABLE VIII.

CAUSES OF DEATH IN FIFTH YEAR OF LIFE. PERCENTAGE OF TOTAL DEATHS AND RATES PER 100,000, EXPANDING REGISTRATION AREA OF THE UNITED STATES 1910-1915, AND METROPOLITAN LIFE INSURANCE CO., INDUSTRIAL DEPARTMENT, WHITE LIVES, 1911 TO 1916.

| Cause of Death. | Per cent. Total Deaths. | | Rate per 100,000. | |
|---|-------------------------|------------|-------------------|------------|
| | Reg. Area. | M.L.I. Co. | Reg. Area. | M.L.I. Co. |
| All causes. | 100.0 | 100.0 | 489.9 | 576.0 |
| Typhoid fever. | 2.2 | 2.0 | 10.6 | 11.5 |
| Measles. | 3.5 | 4.5 | 17.1 | 25.6 |
| Scarlet fever. | 7.6 | 7.4 | 37.3 | 42.8 |
| Whooping cough. | 2.4 | 2.5 | 11.5 | 14.4 |
| Diphtheria and croup. | 18.8 | 22.2 | 92.3 | 128.0 |
| Tuberculosis—all forms. | 7.7 | 7.0 | 37.6 | 40.4 |
| Tuberculosis of the lungs. | 2.5 | 1.7 | 12.3 | 9.6 |
| Tuberculous meningitis. | 3.8 | 4.1 | 18.4 | 23.4 |
| Organic diseases of the heart. | 1.6 | 1.2 | 7.8 | 6.6 |
| Bronchitis. | 1.1 | 1.2 | 5.2 | 7.0 |
| Bronchopneumonia. | 6.0 | 6.4 | 29.2 | 35.6 |
| Pneumonia—lobar and undefined. | 6.8 | 6.3 | 33.5 | 36.2 |
| Diarrhea and enteritis. | 5.0 | 5.3 | 24.5 | 30.6 |
| Appendicitis. | 1.4 | 1.0 | 7.0 | 5.5 |
| Burns. | 5.7 | 5.5 | 28.1 | 31.6 |
| Traumatism by fall. | 1.1 | .9 | 5.2 | 5.1 |
| Total vehicular accidents. | 2.5 | 2.5 | 12.3 | 14.2 |
| Automobile accidents and injuries. | .8 | .9 | 3.8 | 5.3 |

THE SECOND QUINQUENNIAL OF LIFE—AGES 5 TO 9 YEARS.

The second five years of life are characterized by extremely low mortality rates in both experiences of population and insured children. The interrelations between the several causes of death are in the main different from those we have previously described. We are now concerned with a very much larger list of diseases and conditions, a considerable number of which have made their appearance for the first time in any appreciable degree. These include certain organic conditions which are indicative of degenerative processes. Of the epidemic diseases of childhood only two now merit attention, scarlet fever and diphtheria. Measles and whooping cough play comparatively minor parts in the total mortality between ages 5 and 9. Typhoid fever has increased to a respectable figure, 3.7 per cent. of all deaths and a rate of 11.0 per 100,000 for general population children, and 2.9 per cent. and a rate of 10.0 per 100,000 for insured children. Tuberculosis becomes a little more important as a factor of mortality in this period and from now on will be found to increase continuously in its rate for a long period of years. Tuberculous meningitis for the first time in childhood becomes a less important form of this disease than pulmonary tuberculosis. Pneumonia, all forms, is still among the more prominent causes of death; and bronchopneumonia has fallen much below lobar pneumonia in its incidence. Appendicitis has approximately the same mortality rate as typhoid fever in both general population and insurance experiences. The accidents and injuries are prominent and such conditions as falls, accidental drowning and the vehicular accidents, chief of which are the automobile accidents, demand more and more of our attention.

Concerning the organic conditions referred to above, we must direct especial attention to acute articular rheumatism, diabetes, acute endocarditis, organic diseases of the heart and acute nephritis and Bright's disease. Some of these are undoubtedly idiopathic but most of them, probably, are either the immediate or ultimate sequelae of the epidemic diseases of childhood.

TABLE IX.

CAUSES OF DEATH IN SECOND QUINQUENNIAL OF LIFE. PERCENTAGE OF TOTAL DEATHS AND RATES PER 100,000, EXPANDING REGISTRATION AREA OF THE UNITED STATES 1910-1915, AND METROPOLITAN LIFE INSURANCE CO., INDUSTRIAL DEPARTMENT, WHITE LIVES, 1911 TO 1916.

| Cause of Death. | Per cent. Total Deaths. | | Rate per 100,000. | |
|--|-------------------------|------------|-------------------|------------|
| | Reg. Area. | M.L.I. Co. | Reg. Area. | M.L.I. Co. |
| All causes. | 100.0 | 100.0 | 317.2 | 348.7 |
| Typhoid fever. | 3.7 | 2.9 | 11.6 | 10.0 |
| Measles. | 2.5 | 3.1 | 7.8 | 10.9 |
| Scarlet fever. | 7.1 | 6.8 | 22.5 | 23.8 |
| Whooping cough. | 1.2 | 1.1 | 3.9 | 3.9 |
| Diphtheria and croup. | 15.8 | 19.8 | 50.2 | 69.1 |
| Tuberculosis—all forms. | 8.7 | 8.0 | 27.7 | 27.8 |
| Tuberculosis of the lungs. | 3.5 | 2.7 | 11.2 | 9.4 |
| Tuberculous meningitis. | 3.4 | 3.7 | 10.7 | 12.7 |
| Acute articular rheumatism. | 2.0 | 2.3 | 6.4 | 8.0 |
| Diabetes. | .9 | .5 | 3.0 | 1.7 |
| Acute endocarditis. | 1.3 | 1.2 | 4.3 | 4.2 |
| Organic diseases of the heart. | 4.4 | 4.8 | 14.0 | 16.6 |
| Bronchitis. | .7 | .7 | 2.2 | 2.5 |
| Bronchopneumonia. | 3.5 | 3.5 | 11.1 | 12.2 |
| Pneumonia—lobar and undefined. | 5.9 | 5.1 | 18.7 | 17.7 |
| Diarrhea and enteritis. | 2.5 | 2.4 | 8.0 | 8.3 |
| Appendicitis. | 3.5 | 2.9 | 11.2 | 10.2 |
| Acute nephritis. | 1.4 | .9 | 4.3 | 3.2 |
| Bright's disease. | 1.3 | 1.2 | 4.3 | 4.2 |
| Burns. | 2.7 | 2.7 | 8.6 | 9.6 |
| Accidental drowning. | 2.6 | 3.0 | 8.3 | 10.6 |
| Traumatism by fall. | 1.3 | 1.2 | 4.1 | 4.2 |
| Total vehicular accidents. | 4.4 | 5.0 | 13.9 | 17.5 |
| Automobile accidents and injuries. | 1.8 | 2.5 | 5.6 | 8.8 |

THE THIRD QUINQUENNIAL OF LIFE—AGES 10 TO 14 YEARS.

This age group is characterized by the lowest mortality rate of any divisional period of life. In fact, for all causes of death combined the rate, 2.2 per 100,000 in both the population and insurance experience is less than the rate for some individual diseases in some age quinquennia. The few deaths which do occur in this closing age period of childhood are distributed over a large number of single conditions or causes of death, not any one of which is of great numerical importance. Tuberculosis is the chief cause of death in this divisional period of life, being responsible for 14.8 per cent. of all deaths in the population experience and for 12.8 per cent. in the insurance experience. The death rate for tuberculosis was 32.7 per 100,000 for children in the general population and 28.6 for insured children at this age period. Of these tuber-

culosis deaths, two thirds are of the pulmonary type. Abdominal tuberculosis appears for the first time as a significant cause of death, and requires notice as does also tuberculous meningitis. Typhoid fever has a higher rate than in the preceding age group, but shows a lower mortality rate among insured than among the population children. Appendicitis, likewise, shows an increased prominence in both series in this quinquennium.

Measles and whooping cough are no longer of any great consequence as causes of death in this age period. Scarlet fever and diphtheria give significant mortality figures for the last time. Between 10 and 15 years of age scarlet fever accounts for 3 per cent. of the deaths in both experiences and diphtheria for approximately 6 per cent. of the deaths. The respiratory diseases and conditions show satisfactory declines from the rates in earlier age periods. In this age period pneumonia mortality shows its lowest rate of incidence in any age period of life.

The acute infections, generally, are now replaced in significance by such grave diseases as organic diseases of the heart, acute articular rheumatism, diabetes and acute endocarditis. Organic diseases of the heart are responsible for 12.0 per cent. of the deaths among insured children and for 8.6 per cent. of the deaths among population children of this age group. Acute articular rheumatism showed a ratio of 3.0 per cent. of all deaths for population children and 3.4 per cent. for insured children. Diabetes showed a higher percentage and death rate among children in the general population.

Nephritis and Bright's disease together accounted for 3.5 per cent. of all the deaths among population children and for 2.9 per cent. among insured children.

Accidents and injuries as a group occupied a prominent position in the total mortality, and the vehicular accidents as well as accidental drowning and traumatism by firearms are especially important as causes of death ascribed to this third quinquennium.

Considered by sex, we find that males have a slightly higher mortality from measles, from scarlet fever, bronchopneumonia, and pneumonia, lobar and undefined. For traumatism by fall

males show a rate of 4.8 per 100,000 which may be compared with a figure of 1.3 for females in the general population. Automobile accidents and injuries had a rate of 5.5 per 100,000 for males and 1.0 per 100,000 for females in the third quinquennium of life.

The facts available for this age group in both the population and insurance experience are shown in the following Table X.

TABLE X.

CAUSES OF DEATH IN THIRD QUINQUENNium OF LIFE. PERCENTAGE OF TOTAL DEATHS AND RATES PER 100,000, EXPANDING REGISTRATION AREA OF THE UNITED STATES 1910-1915, AND METROPOLITAN LIFE INSURANCE CO., INDUSTRIAL DEPARTMENT, WHITE LIVES, 1911 TO 1916.

| Cause of Death. | Per cent. Total Deaths. | | Rate per 100,000. | |
|------------------------------------|-------------------------|------------|-------------------|------------|
| | Reg. Area. | M.L.I. Co. | Reg. Area. | M.L.I. Co. |
| All causes..... | 100.0 | 100.0 | 220.4 | 224.0 |
| Typhoid fever..... | 6.4 | 5.8 | 14.2 | 12.9 |
| Measles..... | 1.0 | .7 | 2.2 | 1.6 |
| Scarlet fever..... | 3.0 | 3.0 | 6.6 | 6.7 |
| Whooping cough..... | .2 | .1 | .5 | .3 |
| Diphtheria and croup..... | 5.6 | 6.4 | 12.2 | 14.2 |
| Tuberculosis—all forms..... | 14.8 | 12.8 | 32.7 | 28.6 |
| Tuberculosis of the lungs..... | 10.2 | 8.5 | 22.4 | 19.0 |
| Tuberculous meningitis..... | 2.2 | 2.1 | 4.7 | 4.7 |
| Abdominal tuberculosis..... | 1.0 | .8 | 2.2 | 1.7 |
| Acute articular rheumatism..... | 3.0 | 3.4 | 6.6 | 7.7 |
| Diabetes..... | 2.2 | 1.6 | 4.9 | 3.6 |
| Acute endocarditis..... | 1.8 | 1.9 | 3.1 | 4.2 |
| Organic diseases of the heart..... | 8.6 | 12.0 | 18.9 | 27.0 |
| Bronchitis..... | .3 | .3 | .7 | .6 |
| Bronchopneumonia..... | 1.4 | 1.3 | 3.2 | 2.9 |
| Pneumonia—lobar and undefined..... | 5.3 | 4.5 | 11.7 | 10.1 |
| Diarrhea and enteritis..... | .9 | .9 | 2.1 | 2.1 |
| Appendicitis..... | 6.3 | 6.3 | 13.8 | 14.1 |
| Acute nephritis..... | 1.2 | .8 | 2.7 | 1.8 |
| Bright's disease..... | 2.3 | 2.1 | 5.0 | 4.7 |
| Burns..... | 1.0 | 1.1 | 2.2 | 2.4 |
| Accidental drowning..... | 4.4 | 6.0 | 9.7 | 13.4 |
| Traumatism by firearms..... | 1.9 | 1.3 | 4.1 | 2.9 |
| Traumatism by fall..... | 1.4 | 1.3 | 3.1 | 3.0 |
| Total vehicular accidents..... | 4.4 | 5.3 | 9.6 | 11.9 |

SUMMARY OF MORTALITY OF CHILDHOOD.

We have presented in some detail the main facts of mortality in each of the age classes of childhood. We may now summarize our discussion for the entire period, considering primarily the characteristics of the principal groups of causes of death affecting children.

We may conveniently group these causes of death under six heads as follows:

rate in the second, third and fourth years of life which varies but little from the maximum point of 49.7 per 100,000 in the third year of life. The other three of these chief epidemic diseases of childhood seem to rise sharply to a maximum and to decline fairly rapidly after the point of highest incidence. Only diphtheria and scarlet fever continue to show serious mortality rates after the period of childhood.

With the exception of whooping cough, the death rate for these diseases is higher for males than for females during the first five years of life. After the fifth year of life the mortality rates of measles, scarlet fever and diphtheria for the two sexes are not markedly different. For whooping cough the mortality rates are considerably higher for females throughout the entire period of childhood but the percentage of excess female mortality is greatest in the third year of life.

V. ACCIDENTS AND INJURIES.

Accidents and injuries are a significant group of causes of death in childhood. Burns, falls, automobile and other vehicular accidents and injuries, drowning and accidental poisonings constitute the chief single causes of accident mortality at these ages. Burns account for an appreciable percentage of the total mortality from the second to the fifth year of life. Falls play an important part in the deaths between the second and fourth year of life and show much higher mortality rates at each of the ages of childhood among males than among females. The vehicular accidents have their maximum incidence at the age period 5 to 9 years. The automobile is the chief agency in the causation of these deaths.

VI. IMPORTANT INFECTIOUS AND ORGANIC DISEASES OF MISCELLANEOUS ORDER.

There remain a miscellaneous group of diseases which we have not considered under any of the preceding five main groups of causes of death in children. This group includes the organic diseases of the heart, the acute and chronic diseases of the kidneys, acute articular rheumatism, acute endocarditis, diabetes, appendicitis, and tuberculosis, especially tuberculous meningitis.

The organic diseases of the heart first begin to assume prominence in the fourth year of life and increase in frequency up to the age period 10 to 14 years where we record the maximum rate in childhood. Diseases of the kidneys likewise are of significance first in the fourth year of life. The maximum rate for acute nephritis is found between 3 and 4 years, and the minimum between 10 and 14 years. These deaths in many instances follow the acute infectious diseases, scarlet fever chiefly. Bright's disease is of some importance in the second and third quinquennia of childhood. Chronic Bright's disease in childhood is also closely associated with the acute infectious diseases of the earlier ages but the number of deaths continues to be important in the second and third quinquennia. Acute endocarditis and acute articular rheumatism may be considered together, because of the frequent clinical association of the two conditions. We record a significant rate of mortality between ages 5 and 9 years from both of these conditions. Appendicitis is an important cause of mortality beginning with the fourth year of life and increases in incidence throughout childhood.

Tuberculosis is a leading cause of death throughout all the ages of childhood. The rate is highest in the first year of life; it decreases to a minimum in the period 5 to 9 years, and rises thereafter. Tuberculous meningitis is the chief form of tuberculosis in the first ten years of life. Tuberculosis of the lungs shows its minimum rate in the period 5 to 9 years, but beginning with the quinquennium 10 to 14 years, the mortality for tuberculosis of the lungs rises to first importance and continues to hold its place as the leading cause of death for several age periods thereafter.

CONCLUSIONS AND RECOMMENDATIONS.

The following conclusions and recommendations suggest themselves from this analysis of the mortality statistics of childhood.

There is opportunity and need for concentrating the efforts of the public health movement upon the further reduction of mortality in childhood. The work of community health agencies during the past twenty years has shown clearly the

large possibilities for life conservation when directed at the preventable causes of infant and child mortality. The reduction of infant mortality has become a definitely established part of the public health programme. Much additional saving can be accomplished by attacking especially the group of diseases which we have included under the heading of prematurity, congenital debility and malformations, etc. The extension of effective prenatal work and the provision of greater facilities for competent obstetrical and nursing aid in childbirth will accomplish very material reductions in mortality from this group of causes which constitute so large an element in the destruction of child life. Practical experience in prenatal work in a number of cities, especially in Boston, Massachusetts, has already demonstrated the exceptional opportunities for the saving of maternal and infant life which await the broadening public health programme in the United States.

The so-called "pre-school" years of childhood have as yet received very little attention from the life conservation movement. Much preventable mortality is in evidence at these ages beyond infancy and under the school years. Sickness and mortality from the acute epidemic infections, and especially from the more serious complications of these diseases, are still in evidence and constitute a challenge to our best efforts for their control. Diphtheria is still a very grave menace to child life at these pre-school years. The extensive development of child welfare clinics, patterned very much after infant welfare stations, seems to be indicated by the facts of our inquiry. While their primary function should be, perhaps, the control of nutritional diseases, the work of such clinics may well result in a reduction of the sickness and mortality rate of the acute epidemic diseases through an increase in the physical resistance of children and by the dissemination of hygienic knowledge to mothers.

The years of school life show comparatively low mortality rates; but even at this period, mortality is capable of still further reduction through additional public health welfare activities for children. There can be more complete coöperation between the medical authorities in schools and those

engaged in health conservation work outside the schools. School medical inspection and school nursing are still far from universally available for school children, especially in rural communities and in small cities. Where such medical and nursing service is available to school children, much still remains to be done to make this form of public health service more efficient and in line with practice which has stood the test of experience in the larger centers of population.

Finally, we must seek earnestly to improve our sources of information on child life. Our available records of the number and of the characteristics of American children according to single years of life are indeed faulty. This is especially true for the early ages in childhood, including infancy. Effective health work is conditioned at almost every point by the completeness and reliability of our statistical information. American statisticians, including registrars of vital statistics, and the medical profession generally, should combine all their effective forces to make birth registration once and for all reasonably complete on a nation-wide basis. Similarly we must strive to secure a greater measure of success in the enumeration of the population at the child ages in the Census of 1920. Accurate census returns of the child population of the United States, together with improved birth registration, the extension and refinement of death registration, and the critical statistical analysis of child mortality will place data at our disposal for practical service in the saving of child life, not only in infancy but at the ages of childhood as well.

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